TRANSACTIONS

OF

THE AMERICAN PHILOSOPHICAL SOCIETY.

ARTICLE I.

Observations to determine the Magnetic Dip at various places in Ohio and Michigan. By Elias Loomis, Professor of Mathematics and Natural Philosophy in Western Reserve College. In a letter to Sears C. Walker, Esq., M. A. P. S. Read June 21st, 1839.

THE instrument employed for the following observations was made by Gambey, for Western Reserve College. The vertical circle upon which the dip is read is graduated to ten minutes, which I am accustomed to divide, by estimation, to single minutes, by the aid of two microscopes attached to the glass case which covers the instrument. This circle is made of copper, and plated with silver. The horizontal circle is graduated to half degrees, and reads by a vernier to single minutes. The axis of the needle rests upon agate supports, and is centred by two copper y's. A sensitive level is attached to the instrument, which rests upon three adjusting screws. The two needles which accompany the instrument are each of them nine inches and six tenths in length. Their breadth, in the middle, is a half inch, and they terminate at each extremity in a sharp point. They have, throughout, a uniform thickness of about the fortieth of an inch.

The observations were invariably made in an open area, at the distance of several rods from any building, or any apparent local cause of attraction. Particular care was taken to remove all iron in the form of knives, keys, &c. The instrument was placed upon a solid block of wood of convenient height, and levelled. The vertical circle was then turned in azimuth until the needle assumed a vertical position, and the azimuth read off from the horizontal circle. The needle was then turned upon its supports, (the north extremity of the axis to the south,) and the observation repeated. Needle No. 1, in which the distribution of the magnetism was most uniform, was always used for this purpose, and the two readings ordinarily differed by less than a degree. The mean of the two was taken as indicating the vertical plane at right angles to the magnetic meridian. In order to test the degree of accuracy of which the method is susceptible, I made repeated observations at Hudson, where I had a meridian mark, and knew the variation of the needle. The preceding method was found to give the magnetic meridian within a fraction of a degree. Let us inquire what influence such an error would produce upon the observed dip.

Put δ = the dip in the magnetic meridian.

δ' = the dip in any vertical plane.

A = the magnetic azimuth of the plane in which δ' is observed. Then we shall have $\text{tang}\ \delta' = \text{tang}\ \delta.\ \text{sec. A.}$; from which formula we learn that at Hudson the dip increases less than one minute, from being observed two degrees out of the magnetic meridian. The method employed for determining the magnetic meridian possesses, therefore, all the accuracy which could be desired for this purpose.

Both needles were observed at each station, and an equal number of times. In needle No. 1 the magnetic axis was found always to coincide very nearly with the geometrical axis. Although I have reversed the poles more than a dozen times, the inclination of the magnetic axis to the geometrical has never exceeded a small fraction of a degree. In needle No. 2, although it has been magnetized in the same way, and its poles reversed the same number of times, the magnetic axis has invariably been found quite oblique to the geometrical axis, the inclination varying from one to three degrees. For reversing the poles I always employ a bar magnet of about a foot in length. I draw the flat side of one half the needle over a pole of the magnet; then the opposite side

over the same pole. The other half of the needle I apply, in a similar manner, to the opposite pole of the magnet, and repeat the entire operation three times. In each set of observations the poles of the needles are reversed, and the same number of observations made in the two magnetic states of the needle. My mode of observing is as follows:—Having brought the plane of the vertical circle into the magnetic meridian by the method already explained, with the face of the instrument to the east, and the marked side of the needle also to the east, I read off the graduation at both extremities of the needle. I do not, ordinarily, wait for the needle to come to a state of entire rest, but when the arc of vibration is reduced to ten or fifteen minutes, take the mean of the extreme oscillations. Without disturbing the position of the instrument, I now vibrate the needle, centring it, and at the same time checking its vibrations by the copper y's. When the arc of vibration is sufficiently reduced, I read off again, as before. I repeat the same operation five times, thus obtaining ten readings in the same position of the instrument and needle. These readings are commonly nearly identical. In two or three instances, however, the extreme readings have differed from each other to the amount of about forty minutes. This occasional sluggishness of the needle may, perhaps, be ascribed to moisture, or minute particles of dust settling upon the axis of the needle and upon the agate supports, and acting, by friction, to retain the needle at rest, though out of the position it would naturally assume. Leaving still the instrument in its first position, I turn the east side of the needle to the west, and make ten readings as before. Turning, then, the face of the instrument to the west, I repeat the observations in the same order, making forty readings in one magnetic state of the needle. Reversing the poles, I repeat the entire operation, which gives me eighty readings with one needle. The other needle furnishes the same number of readings, making a hundred and sixty in all; and this is the number actually taken at each of the places mentioned below, with the exception of Hudson, where the observations were still more numerous. The preceding method was adopted in all of the observations, with the exception of those made at Hudson in September, 1838, where only two readings (one of each pole) were made in each position of the needle, but the system of reversal was precisely the same as that above described.

Magnetic Dip at Hudson, Ohio. Latitude 41° 15′ *N.; Longitude* 81° 24′ *W.*

The place of observation was the college yard, distant several rods from the buildings, and the instrument was placed upon a solid block of wood, which was due north from the transit instrument of the observatory.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1838, Sept. 4	11—12, A. M.	No. 2	16	72° 54′·3
5	5—6, P. M.	1	16	40 ·5
6	11—12, A. M.	1	16	54 ·3
6	" " "	2	16	34 ·8
7	11—12, A. M.	1	16	57 ·2
20	10—11, A. M.	2	16	48 ·1
Mean of 96 observations in September, 1838, ...				72 48 ·2
1839, April 6	4—5, P. M.	1	80	72 46 ·9
26	9—11, A. M.	2	80	46 ·5
27	9—11, A. M.	1	80	44 ·3
May 1	9—11, A. M.	2	80	49 ·4
Mean of 320 observations in April and May, 1839, ...				72 46 ·8

Magnetic Dip at Cleveland, Ohio. Latitude 41° 30′ *N.; Longitude* 81° 51′ *W.*

The place of observation was by the Lake shore, nearly in front of the American Hotel.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1839, May 9,	8—12, A. M.	No. 1	80	73° 21′·2
" "	" "	2	80	30 ·8
Mean of 160 observations with two needles, ...				73 26 ·0

Magnetic Dip at Detroit, Michigan. Latitude 42° 19′ *N.; Longitude* 83° 3′ *W.*

The place of observation was an open area west of the city, and not far from the Michigan Exchange.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1839, May 11,	2—6, P. M.	No. 1	80	73° 37′·2
" "	" "	2	80	48 ·1
Mean of 160 observations with two needles, ...				73 42 ·6

Magnetic Dip at Ann Arbor, Michigan. Latitude 42° 18′ *N.; Longitude* 83° 45′ *W.*

The place of observation was an open field, a few rods west of the village.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1839, May 14,	4—6, P. M.	No. 1	80	73° 6′·5
" "	" "	2	80	21 ·2
Mean of 160 observations with two needles, ...				73 13 ·9

Magnetic Dip at Ypsilanti, Michigan. Latitude 42° 14′ *N.; Longitude* 83° 38′ *W.*

The place of observation was a hill on the east side of Huron river, a few rods from the village.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1839, May 15,	12—2, P. M.	No. 1	80	73° 11′·9
" "	" "	2	80	24 ·1
Mean of 160 observations with two needles, ...				73 18 ·0

Magnetic Dip at Monroe, Michigan. Latitude 41° 55′ *N.; Longitude* 83° 28′ *W.*

Place of observation an open field, a few rods south-east of the village.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1839, May 16,	4—6, P. M.	No. 1	80	73° 24′·1
" "	" "	2	80	40 ·6
Mean of 160 observations with two needles, ...				73 32 ·3

Magnetic Dip at Toledo, Ohio. Latitude 41° 41′ *N.; Longitude* 83° 33′ *W.*

Place of observation an open field, a few rods west of the village.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1839, May 17,	5—7, P. M.	No. 1	80	73° 1′·2
" "	" "	2	80	10 ·9
Mean of 160 observations with two needles, ...				73 6 ·1

Magnetic Dip at Maumee City, Ohio. Latitude 41° 34′ *N.; Longitude* 83° 38′ *W.*

Place of observation an open field, a few rods north of the village.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1839, May 18,	5—7, P. M.	No. 1	80	72° 50′·8
" "	" "	2	80	47 ·4
Mean of 160 observations with two needles, ...				72 49 ·1

Magnetic Dip at Sandusky City, Ohio. Latitude 41° 29′ *N.; Longitude* 82° 48′ *W.*

Place of observation an open field, a few rods south of the village.

Date.	Hour.	Needle.	No. Readings.	Observed Dip.
1839, May 20,	9—11, A. M.	No. 1	80	73° 0′·0
" "	" "	2	80	72 55·6
Mean of 160 observations with two needles, ...				72 57·8

From the preceding observations, compared with such as have been made in other parts of the United States, and of which a collection may be seen in the American Journal of Science, Vol. xxxiv. p. 308, it will appear that the same dip is found in a higher latitude in the western than in the eastern states. The lines of equal dip, consequently, intersect the parallels of latitude, their direction being from about N. 82° W. to S. 82° E.